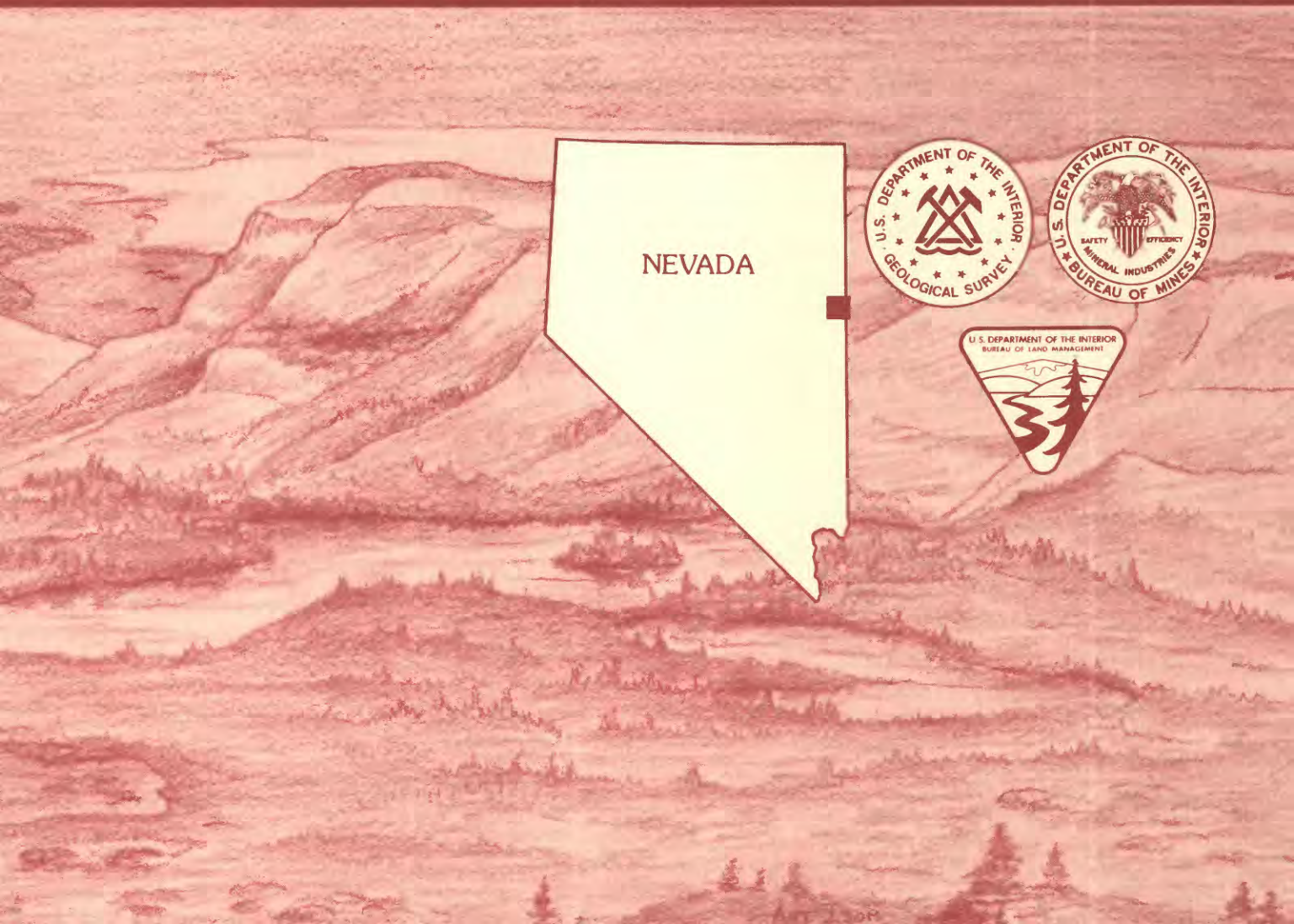


Mineral Resources of the Marble Canyon Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah

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Chapter G

Mineral Resources of the Marble Canyon Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah

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U.S. GEOLOGICAL SURVEY BULLETIN 1728

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
EAST-CENTRAL NEVADA AND PART OF ADJACENT BEAVER
AND IRON COUNTIES, UTAH

U.S. DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary



U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of part of the Marble Canyon (NV-040-086) Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah.

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Mineral Resources of the Marble Canyon Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah

By Michael F. Diggles, Gary A. Nowlan, H. Richard Blank, Jr., and Susan M. Marcus
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SUMMARY

Abstract

The 19,150-acre Marble Canyon Wilderness Study Area (NV-040-086) was evaluated for mineral resources (known) and mineral resource potential (undiscovered), and fieldwork was conducted in 1987. The acreage includes 6,435 acres that is now designated as part of the Mount Moriah Wilderness under the Nevada Wilderness Protection Act of 1989 (S. 974), most but not all of which is included in 8,300 acres for which the U.S. Bureau of Land Management requested a mineral survey. In this report, the "wilderness study area," or simply "the study area" refers to the entire 19,150-acre tract.

The area is underlain by quartzite, shale, and carbonate rocks. The northern Snake Range décollement is a detachment surface that separates rocks of similar age but different metamorphic grade within the study area. Large inferred subeconomic limestone and marble resources in the study area have no special or unique properties. The mineral resource potential for limestone and marble is high in two canyons and is moderate in the rest of the wilderness study area. Parts of the study area above and along the northern Snake Range décollement have low potential for undiscovered deposits of gold, silver, copper, lead, zinc, tungsten, molybdenum, beryllium, and fluorite. A zone around barite-bearing rock penetrated by adits inside the southeast boundary of the study area has moderate potential for barite, and the surrounding area has low potential for barite; both areas also have low potential for silver, copper, lead, zinc, and tungsten. The entire study area has moderate potential for oil and gas and low potential for geothermal energy resources.

Character and Setting

The Marble Canyon Wilderness Study Area covers approximately 19,150 acres and is 5 mi west of Gandy, Utah (fig. 1). The terrain is rugged, and the elevation ranges from about 9,331 ft at Thunder Mountain to about 5,240 ft in the southeast corner of the study area. Access to and within the

study area is by four-wheel-drive vehicle on roads in Marble Wash, Coyote Canyon, Bars Canyon, and Smith Creek.

Most of the study area is underlain by shales, quartzites, and carbonate rocks of early Paleozoic age (see "Appendixes" for geologic time chart). The oldest exposed rocks in the area are shale, quartzite, and marble of Early and Middle Cambrian age. Shale of Late Cambrian age has been faulted over the older metamorphosed rocks. Dolomite and quartzite of Ordovician and Silurian age are also in fault contact with the Upper Cambrian rocks. Small areas of dolomite and limestone of Devonian to Permian age crop out east of the range-front fault; their relation to the rocks west of the fault is obscured by alluvium. The structural history of the study area includes the development of a detachment fault that juxtaposes metamorphosed Paleozoic rocks beneath, and in flat-fault contact with, less metamorphosed to nonmetamorphosed rocks. This detachment surface is part of the northern Snake Range décollement.

Identified Mineral Resources

Limestone has been prospected and quarried in and near the study area. Large inferred subeconomic limestone and marble resources inside the study area are without special or unique properties. The carbonate rocks are suitable for use in aggregate, but there are no nearby markets and similar quality resources are present elsewhere.

The exposed northern Snake Range décollement within the study area is not mineralized, as indicated by a lack of surface expressions and by stream-sediment data. Samples taken from fault-breccia zones in nonmetamorphosed carbonate rocks above the northern Snake Range décollement contain some pathfinder elements typical of detachment-related deposits, but no mineral occurrences were observed.

Mineral Resource Potential

In the lower parts of Bars Canyon and Marble Wash the mineral resource potential for limestone and marble is high, and in the rest of the study area it is moderate.

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Areas of the Marble Canyon Wilderness Study Area underlain by upper-plate rocks and the zone of the northern Snake Range décollement have low mineral resource potential for gold, silver, copper, lead, zinc, tungsten, molybdenum, beryllium, and fluorite. The gold and silver are associated with low-angle faults within those areas. Geochemical evidence suggests the resource potential for copper, lead, zinc, tungsten, and molybdenum in those areas. The geophysical study suggests that no plutons are buried beneath the study area, but anomalous concentrations of beryllium in geochemical samples collected from the study area could be explained by the presence of an undetected buried pluton.

Adits inside the southeast boundary of the study area reveal exposures of barite, and anomalous concentrations of barium were measured in geochemical samples from upper-plate rocks near there. A narrow zone around the adits has moderate mineral resource potential for barite, and the surrounding area has low mineral resource potential for barite. On the basis of geochemical data, the adits and a wider zone around them also have low mineral resource potential for silver, copper, lead, zinc, and tungsten.

The metamorphosed lower-plate rocks, the thin sequences of faulted upper-plate rocks, and the extrusive volcanic rocks exposed in the study area are not conducive to the formation and accumulation of hydrocarbons. The resource potential for oil and gas in the entire study area is moderate, but this assessment may be too high due to the lack of likely source rocks. There are two thermal springs in Spring Valley to the west of the study area and other thermal springs just east of the study area. Range-front faults in the region may provide a conduit for the circulation of thermal water, and such a system could extend into the study area. Therefore, the entire Marble Canyon Wilderness Study Area has low potential for geothermal energy resources associated with low-temperature thermal springs.

INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management and is the result of a cooperative effort by the U.S. Geological Survey and the U.S. Bureau of Mines.

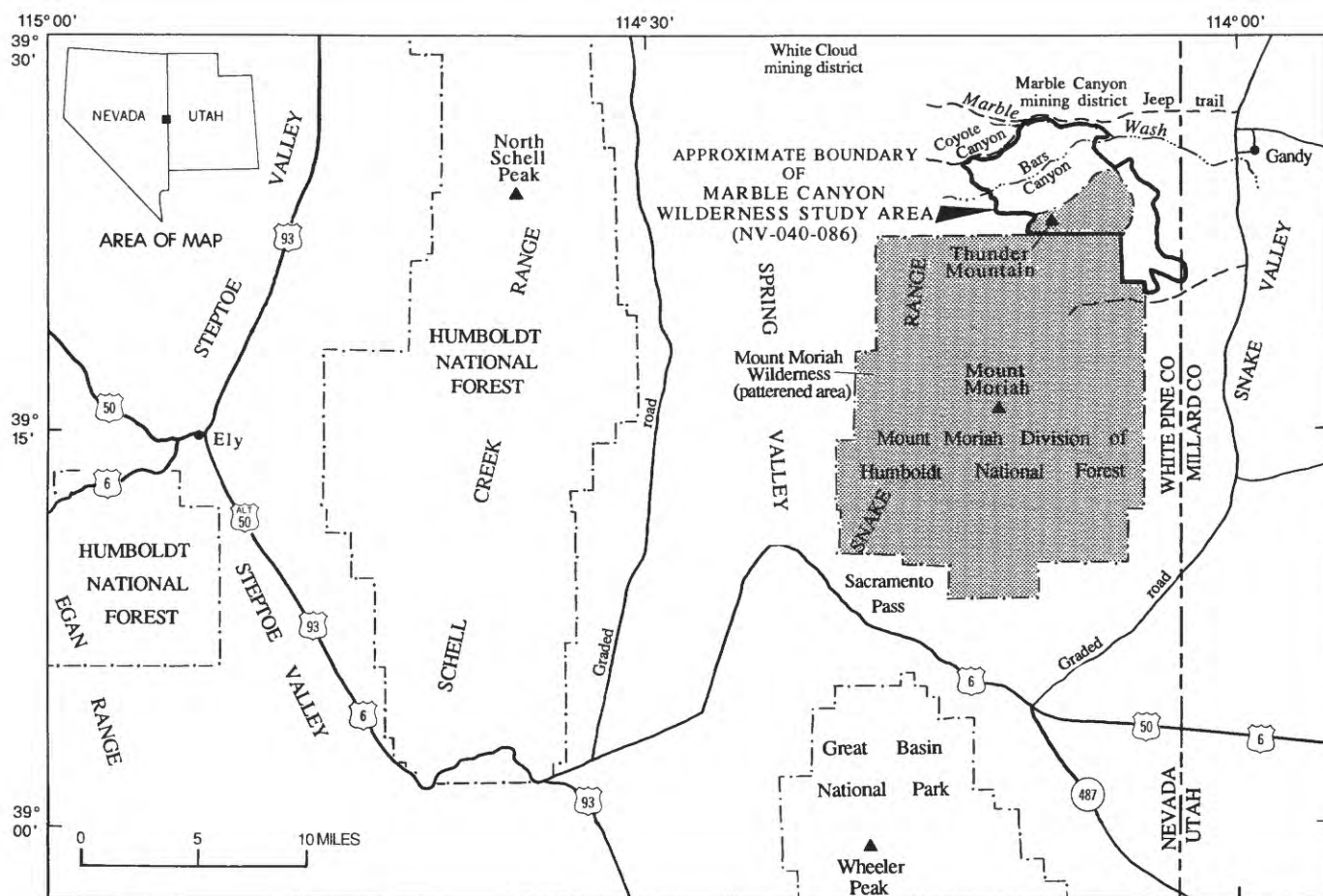


Figure 1. Index map showing location of Marble Canyon Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah.

An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to a system that is a modification of that described by McKelvey (1972) and U.S. Bureau of Mines and U.S. Geological Survey (1980). U.S. Geological Survey studies are designed to provide a scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. Goudarzi (1984) discussed mineral assessment methodology and terminology as they apply to these surveys. See "Appendixes" for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

Location and Physiography

The Marble Canyon Wilderness Study Area comprises approximately 19,150 acres in the Basin and Range physiographic province. It is situated in the northern Snake Range, principally in eastern White Pine County, Nev., but extending a short distance into Millard County, about 5 mi southwest of Gandy, Utah. The north and west boundaries follow Marble Wash and Coyote Canyon, respectively. The south boundary follows an upgraded road from Coyote Canyon to the base of Thunder Mountain and the north boundary of the Mount Moriah Division of Humboldt National Forest. The east boundary follows an upgraded road along the alluvial apron near the 6,000-ft contour. Elevations in the study area range from about 9,331 ft at Thunder Mountain to about 5,240 ft in the southeast corner of the study area. The Nevada Wilderness Protection Act of 1989 designates 6,435 acres of the study area as part of the Mount Moriah Wilderness (fig. 1).

Climate in the study area is classified as arid; precipitation averages 10 in. per year and supports vegetation of the Sonoran and Transition Zones. The higher elevations are in the Transition Zone where vegetation includes piñon and bristlecone pine. Bristlecone pines grow primarily on limestone and are conspicuously absent from hillsides underlain by quartzite. The middle elevations are in the Upper Sonoran Zone and support white fir and incense cedar. On the dryer lower slopes, the vegetation is typically Lower Sonoran sagebrush and mountain mahogany.

Procedures and Sources of Data

The U.S. Geological Survey and the U.S. Bureau of Mines conducted detailed field investigations of the Marble

Canyon Wilderness Study Area in the summer of 1987. This work included geologic mapping at a scale of 1:24,000, field checks of existing geologic maps, geochemical sampling, and the examination of outcrops for evidence of mineralization.

A detailed literature search was made for geologic and mining information pertinent to the study area, and U.S. Bureau of Land Management records were examined for information on mining claims and oil and gas leases. Two U.S. Bureau of Mines geologists spent 6 days in the field for ground reconnaissance and an examination of prospects within and near the study area, and they collected 21 rock and 19 stream-sediment samples. Those samples were analyzed either by inductively coupled plasma-atomic emission spectroscopy or fire assay-atomic absorption methods by Chemex Labs Inc., Sparks, Nev. Sample data were discussed by Kness (1989) and are summarized in this report. Complete sample data are available for public inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO 80225.

General stratigraphic studies in the region include a correlation of stratigraphic units in the Great Basin (Langenheim and Larson, 1973), a description of the stratigraphic section near Eureka, Nev. (Nolan and others, 1956), and paleogeographic interpretations (Stewart and others 1977). Detailed stratigraphic studies include descriptions of upper Precambrian and Lower Cambrian strata (Stewart, 1970), Lower and Middle Cambrian strata (Robison, 1960), and Upper Cambrian strata (Palmer, 1960). Whitebread and Lee (1961) and Whitebread (1969) described the geology of the Wheeler Peak area in what is now Great Basin National Park, 15 mi south of the study area. Hose and Blake (1970, 1976) compiled existing and original geologic mapping of White Pine County, and Hose (1981) presented the geology of the Mount Moriah Division of Humboldt National Forest (formerly the Mount Moriah Roadless Area and now included in the Mount Moriah Wilderness). Christiansen and others (1987) did detailed mapping just south of the study area. The geology in the western part of figure 2 is generalized from detailed mapping by Jeffrey Lee (1990).

General treatments of the structural geology of the region include studies of central northeastern Nevada (Misch, 1960; Misch and Hazzard, 1962) and descriptions of the structural evolution of the eastern Great Basin (Hose and Daneš, 1968, 1973; Hose and Blake, 1969). Hazzard and others (1953) and Nelson (1966) described the structural development of the region, including the large-scale thrust faulting in the northern Snake Range, a theory that has been superseded by the interpretation of the northern Snake Range décollement (Wernicke, 1981; Miller and others, 1983). Whitebread (1966), Coney (1974), Rowles (1982), and McGrew (1986) specifically addressed the northern Snake Range décollement. Gering (1987), Miller and others (1988b), Huggins (1989), and Jeffrey Lee (1990) discussed the metamorphic history of the Snake Range.

General treatments of mineral resources include a bibliography of Nevada resources (Weimer-McMillion and others, 1983), a map of resource areas in Nevada (Wong, 1983), and a description of computer-accessible Nevada mineral resource data (Sherlock and Tingley, 1985). Cox and Singer (1986) presented models of mineral deposits and of grade and tonnage. Lincoln (1923) provided an early treatment of mining districts in Nevada. Morton and others (1977) provided age data on ore deposits in Nevada. Darton (1908) reported on marble in White Pine County. Smith (1976) reported on the mineral resources of White Pine County, and Carlson and others (1984) presented the mineral resource potential of the Mount Moriah Division of Humboldt National Forest. In 1983, this study area was included in a U.S. Bureau of Land Management Geology, Energy, and Minerals (GEM) inventory program (Great Basin GEM Joint Venture, 1983). Bullock and others (1989) presented the data from the U.S. Geological Survey stream-sediment sampling program for this wilderness study area. Kness (1989) presented the results of the U.S. Bureau of Mines mineral resource appraisal for this wilderness study area.

Acknowledgments

The authors greatly appreciate the cooperation of Shaaron Netherton, William D. Robison, and Brian Amme of the U.S. Bureau of Land Management in Ely, Nev. Carl and Sheriton Baker made the Horse Canyon spring on their ranch available for a field camp site. Jeffrey Lee shared unpublished mapping that is part of his Ph.D. dissertation at Stanford University. Elizabeth Miller and her students from Stanford University shared detailed geologic mapping information on the northern Snake Range. R.A. Schreiner assisted the U.S. Bureau of Mines author with his field studies.

APPRAISAL OF IDENTIFIED RESOURCES

By Richard F. Kness
U.S. Bureau of Mines

Mining Activity

No mining has occurred, but prospecting and limestone quarrying have taken place in the study area. Unpatented mining claims for marble are recorded along parts of Bars Canyon and Marble Wash within the study area and north of it. The following information on nearby mining districts and a mining area is summarized from Hose and Blake (1976) and Smith (1976).

The Marble Canyon mining district encompasses the Marble Wash area and the region north of it (fig. 1). Marble claims were first located in 1891. No production records are available, but small quantities of marble were quarried for grave headstones and transported to Garrison, Utah, 30 mi to

the south. Darton (1908) investigated the marble as a building stone source. Pink-colored marble was tested for crushed stone from 1966 to 1969. Results of these tests have not been located.

The White Cloud mining district is just northwest of the Marble Canyon district (fig. 1; Kness, 1989). The Lead King mine, the only one in the district, is near the summit of White Cloud Mountain, 7 to 8 mi northwest of the study area. Recorded district production from 1949 to 1952 totaled 92 tons of ore containing a trace of gold, 197 oz silver, 225 lb copper, 25,985 lb lead, and 1,553 lb zinc valued at \$4,481 at the time it was mined. No other mining information on the district was found.

The Mount Moriah mining area, in the Humboldt National Forest, is named for mines and prospects on and around Mount Moriah (fig. 1). This mining area has produced quartzite building stone, garnet abrasives, gold, silver, copper, lead, and zinc (Wood, 1983). The Grand View tungsten prospect is on the west slope of Mount Moriah. An assay of coarse-grained scheelite enclosed in 3 ft of silicified limestone shows as much as 7 percent tungsten oxide (WO_3).

Oil and Gas

Drilling has occurred near the north boundary of the study area. A dry-hole marker was located in Marble Wash (fig. 2), but no records were located. Oil and gas leases have been filed near and on the east boundary of the study area (fig. 2).

Results of Field Investigation

Smith Creek Adits

The two short Smith Creek adits are just inside the south boundary of the study area (fig. 2). Barite, calcite, and manganese oxide are in northeast-striking detachment-fault breccia zones in upper-plate limestone. The breccia zones could not be traced beyond the workings due to surface talus. Christiansen and others (1987) mapped this upper-plate limestone as an unnamed Middle Cambrian carbonate unit. Samples of fault breccia contain anomalous amounts of arsenic, beryllium, bismuth, mercury, molybdenum, tungsten, and especially barium and manganese (Kness, 1989, fig. 2). Gold and uranium were not detected, and silver was at detection limits (0.2 ppm). No resources could be defined. The unpatented mining claim 0.5 mi west of the adits is shown in U.S. Bureau of Land Management records, but no evidence of workings was found.

Limestone and Marble

Large inferred limestone and marble resources are present in the study area but must meet industry standards

or specifications in order to be marketable. Limestone and marble are carbonate rocks of essentially the same composition and are used in the chemical and construction industries. They have the same end uses and are cut, crushed, or ground to produce a wide variety of stone products. Other types of rocks may be utilized or substituted for carbonate rocks: granite, sandstone, and slate may be used as dimension or cut stone, and sand and gravel is frequently used as an alternative to crushed limestone or marble.

Impurities such as chert, clay, iron, organic matter, and silica may affect utilization of carbonate rock. Pure calcitic or dolomitic marble is white; any coloration results from impurities. Gray, pink, and white marble were noted during the field investigation. The quartz content of the upper marble units in the northern Snake Range is high; it averages 15 to 20 percent but may be as high as 40 percent (Nelson, 1969, p. 335). Therefore the marble is too impure to be marketable.

Most chemical uses require high-calcium limestone containing more than 95 percent calcium carbonate (CaCO_3); some uses specify more than 97 percent CaCO_3 (Carr and Rooney, 1983). Limestone and marble samples in and near the study area contain CaCO_3 ranging from 75.73 to 94.83 percent (Kness, 1989, table 2); thus, the best material in the study area is of marginal quality. In general, marble samples contain a higher percentage of magnesium carbonate than limestone samples and thus are unlikely to be suitable for chemical uses.

Limestone and marble may be cut and used as dimension stone. Principal uses are in building construction and monuments. Most dimension marble is cut into thin slabs (0.875 to 1.25 in.) for use as veneer or curtain wall construction. Quarry blocks typically weigh 15 to 30 tons and may be rejected for unacceptable color or, more commonly, structural unsoundness (cracks, joints, or fractures). Because most bedded deposits are sawed parallel to bedding, small-scale folds may make it impossible to saw satisfactory slabs. Some marble units in the study area are contorted, folded, and fractured. Dimension-stone quarries in general produce a large amount of waste because only about 25 percent of the quarried stone is sent to the mill for sawing, and 50 percent of that may be lost during manufacturing (see Power, 1972, 1978). A quarry in this area is likely to have higher waste percentages and therefore is less likely to be a viable commercial venture.

Marble dimension stone marketability is governed largely by stone availability and aesthetic qualities (uniform color, patterns, and texture) determined by architects and architectural fashions. A new prospect or deposit may be successful if it matches or closely matches a currently fashionable stone available in large quantities (see Power, 1972). Marble production continues in traditional areas that have favorable geology and market proximity such as the Pittsford district in Vermont and the Tate district in Georgia. Significant tonnage of marble dimension stone is imported from

Italy. Further testing is necessary to determine if marble in and near the study area is suitable for dimension stone. Soundness and aesthetic qualities of the stone are largely unknown. Large inferred resources are present, but impurities, small-scale folds, and fractures are present in some marble units. It is not known whether large, uniform, sound blocks are present. Selective mining might be required if suitable marble units are identified. Transportation costs are high because of weight and the need for special handling to prevent finished-stone damage.

Limestone and marble may be crushed and used as aggregate. A private mining consultant's report (L.C. Armstrong, E.J. Longyear and Co., written commun., 1970) estimated that the Marble Wash deposit contains marble resources totaling 300 million tons, but aggregate is a high-bulk, low-unit-value commodity. In general, hauling crushed stone more than 30 mi is not economical (Schenck and Torries, 1983). The distance from the Marble Wash marble deposits to U.S. Highway 6 and 50 is about 37 mi and Ely, Nev. is the closest market, another 75 mi away. Transportation costs exceed the value of the commodity.

Conclusions

Large inferred subeconomic limestone and marble resources are present in the study area; however, these rocks were determined to have no special or unique properties. Low CaCO_3 content may preclude utilization for chemical purposes. Aesthetic qualities of the marble are unknown, and the presence of impurities, folds, and fractures may make it unsuitable for dimension stone. Even though the carbonate rocks are suitable for use as aggregate, the transportation costs to the nearest markets exceed the unit value, and market areas may use closer carbonate rocks or may substitute other rocks. The remoteness of the area would limit development of the carbonate rocks for all but local uses. Local demand at present is nonexistent. No nearby markets were identified, and resources of similar quality are present elsewhere.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Michael F. Diggles, Gary Nowlan, H. Richard Blank, Jr., and Susan M. Marcus
U.S. Geological Survey

Geology

Rocks not exposed at the surface within the Marble Canyon Wilderness Study Area, but presumably present at depth, include the Proterozoic and Lower Cambrian Prospect Mountain Quartzite, a thick sequence of fine- to medium-bedded quartzite that contains interbeds of argillite.

Exposed rocks in the study area consist of a lower plate of Middle and Upper Cambrian metamorphosed sedimentary rocks in detachment-fault contact with an upper plate of Lower Cambrian through Devonian limestone, dolomite, shale, and quartzite that have mostly undergone only brittle deformation. From Late Proterozoic through Early Triassic, the region of the study area was the site of relatively continuous continental shelf sedimentation (Stewart and others, 1977). Lower-plate rocks were metamorphosed to amphibolite facies during the Cretaceous and underwent retrograde metamorphism to greenschist facies in the Tertiary (J. Lee and others, 1988; Huggins and Wright, 1989; Huggins, 1990; Miller and others, 1988b).

Lower-Plate Rocks

The location of the northern Snake Range décollement and the stratigraphy of the upper and lower plates were modified from the early work of Hose and Blake (1970, 1976) by Jeffrey Lee (1990). The lower plate of the décollement within the study area includes Middle and Upper Cambrian rocks (fig. 2). Elsewhere in the northern Snake Range, the décollement cuts through the Middle Cambrian Pole Canyon Limestone (Huggins and Wright, 1989).

Middle Cambrian rocks consist of the Raiff Limestone of Young (1960) and the Monte Neva Formation of Young (1960). These light-gray to dark-gray metamorphosed limestones are combined on figure 2 (map unit Crm). The Middle Cambrian rocks are interrupted by faulting or erosion everywhere in the study area, and their total thickness is not known.

The Upper Cambrian Notch Peak Limestone and Dunderberg Shale are also combined on figure 2 (map unit Cnd). The Dunderberg consists mostly of light-olive-gray to medium-olive-gray silty shale intercalated with thin beds of limestone. It is only about 70 ft thick in the study area. The Notch Peak Limestone, which underlies most of the study area, is medium gray and massive; locally it is dolomitic and contains lenses of chert. The basal part is thin bedded and silty. Metamorphosed parts of the Notch Peak include the marble for which the area has the highest resource potential. Whitebread (1969) shows a thickness of 1,600 to 1,800 ft for the Notch Peak Limestone south of the study area.

Upper-Plate Rocks

The oldest rocks exposed in the study area are Lower Cambrian shale and quartzite (map unit Csq) that include the Pioche Shale. The Pioche consists of 150 to 600 ft of dark-greenish-gray to olive-gray silty shale and clay shale intercalated with siltstone and includes some sandstone near its base and minor limestone in its upper part. It is exposed in an upper-plate block in the southwest part of the study area. Where the Pioche is metamorphosed within the study area, metamorphic minerals include biotite, muscovite, and garnet.

The undivided Middle Cambrian Monte Neva Formation and Raiff Limestone (map unit Crm) are found in the many small exposures of upper-plate rocks in the northern part of the study area. The Upper Cambrian Notch Peak Limestone is the oldest unit in much of the upper plate, particularly in the southern part of the study area where the northern Snake Range décollement lies within it in most places.

Ordovician rocks in the study area crop out in the upper plate and consist of the undivided Pogonip Group and Eureka Quartzite (map unit Oep). The Pogonip Group in the study area is limited to small outcrop areas near the décollement in the south-central part. It is composed of platy to thin-bedded, fine- to coarse-textured gray detrital limestone. The Eureka Quartzite consists of about 310 ft of white fine-grained equigranular quartzite with minor dolomitic quartzite.

The undivided Ordovician Fish Haven Dolomite and Silurian Laketown Dolomite (map unit Solf) crop out in the south-central part of the study area. These formations consist of light-gray to dark-gray dolomite. South of the study area, chert is locally abundant and the Fish Haven has a dolomitic sandstone at its base.

Outcrops of Devonian rocks in the eastern part of the study area north of Petes Knoll are the undivided Guilmette Formation, Simonson Dolomite, and Sevy Dolomite (map unit Dgs). The Guilmette Formation consists of alternating dolomite and limestone in roughly equal amounts. The Simonson Dolomite is darker gray and commonly more coarsely crystalline. The Sevy Dolomite is medium-gray to medium-light-gray, microcrystalline, well-bedded dolomite with sandy dolomite and quartzite near the top.

Upper Paleozoic rocks also crop out north of Petes Knoll (map unit PMre). The undivided Mississippian to Permian Ely Limestone and Permian Riepe Springs Limestone of Steele (1960) are medium-gray limestones of organic detrital material.

Tertiary Rocks and Quaternary Surficial Deposits

A thin layer of Tertiary volcanic rocks unconformably overlies the Paleozoic rocks on the east side of Petes Knoll. These rocks consist of alkali olivine basalt (map unit Tv). Quaternary surficial deposits include poorly sorted gravel, sand, and silt in stream-channel and flood-plain deposits and landslides (map unit Qal), all of Holocene age. Older Quaternary stream-channel deposits form terraces that are dissected by streams.

Structure and Metamorphism

The presence of metamorphosed Paleozoic rocks beneath, and in flat-fault contact with, less-metamorphosed to nonmetamorphosed rocks in the Snake Range has been discussed since the early 1950's (Hazzard and others, 1953) when the nearly flat fault was interpreted as a thrust fault. The fault was interpreted later to be a detachment fault (Whitebread, 1966; Coney, 1974) that has juxtaposed younger

rocks eastward over older rocks. Detachment faults have been described in many areas of the Western United States on the margins of metamorphic core complexes (Crittenden and others, 1980). Miller and others (1983) interpreted the fault to have undergone little or no horizontal displacement. An early deformation resulted in a northwest trend to the metamorphic fabric in the lower-plate rocks. A later lower-plate metamorphic fabric has a southerly trend that resulted from the Tertiary movement on the northern Snake Range décollement (Coney, 1974).

Rocks that have been metamorphosed to amphibolite facies in the southern Snake Range have been cut by 160-Ma plutonic rocks, thereby constraining the age of the metamorphism to no younger than Jurassic (Miller and others, 1988b). Those rocks that were metamorphosed during the Jurassic have undergone retrograde metamorphism during more recent events.

Cretaceous metamorphism was to upper greenschist or amphibolite facies. The age of metamorphism is inferred to be 78 ± 9 Ma on the basis of uranium-lead zircon and monazite data (D.E. Lee and others, 1981). Jeffrey Lee and others (1988) and Jeffrey Lee (1990) also obtained a Cretaceous age from argon determinations ($^{40}\text{Ar}/^{39}\text{Ar}$) on hornblende. This metamorphism coincides with the time of movement on the Sevier thrust belt east of the study area (Miller and others, 1988a; Miller and Gans, 1989a, 1990). Tertiary metamorphism is shown by ductile strain that produced penetrative foliation in the Paleozoic rocks of the lower plate of the northern Snake Range décollement (Miller and others, 1988b). Potassium-argon ages on micas from lower-plate rocks yield Tertiary ages (D.E. Lee and others, 1970) and $^{40}\text{Ar}/^{39}\text{Ar}$ data show that the rocks were still being deformed as recently as the Miocene (J. Lee and others, 1988; J. Lee, 1990).

The northern Snake Range décollement is interpreted by Miller and others (1983) and Gans and others (1985, 1986) to have developed as a ductile-brittle transition zone at a depth of 3.8 to 4.4 mi. The detachment took place during the doming of the décollement (Miller and others, 1983; McCarthy, 1986) and the extension of this part of the Basin and Range province. The uplift and detachment represent an Oligocene to Miocene event (Miller and others, 1987). The rocks above the décollement underwent two generations of east-dipping high-angle normal faulting as the extension progressed. These high-angle faults do not extend below the décollement (Gans and Miller, 1983).

Basin-and-Range-type high-angle normal faulting in the Snake Range started in the early to middle Oligocene (Gans and others, 1989) and has occurred continuously since then. It is responsible for the relief in the study area and for the formation of Snake Valley to the east. Normal faults cut 35-Ma volcanic rocks (Gans, 1987). Miller and Gans (1989b) put age constraints on the relative uplift of the range and downdropping of the adjacent basins from about 17 to 15 Ma; their data showed that cooling of deeper rocks to below 120 °C occurred from 14 to 11 Ma.

Geochemistry

A reconnaissance geochemical survey of the Marble Canyon Wilderness Study Area was conducted in May 1987. Stream-sediment samples that were collected from all major streams and tributaries represent eroded bedrock that underlies the drainage basin whence the sediment came. Panned concentrates of the sediment were prepared and analyzed separately. The panned-concentrate fraction may contain minerals related to mineralization processes.

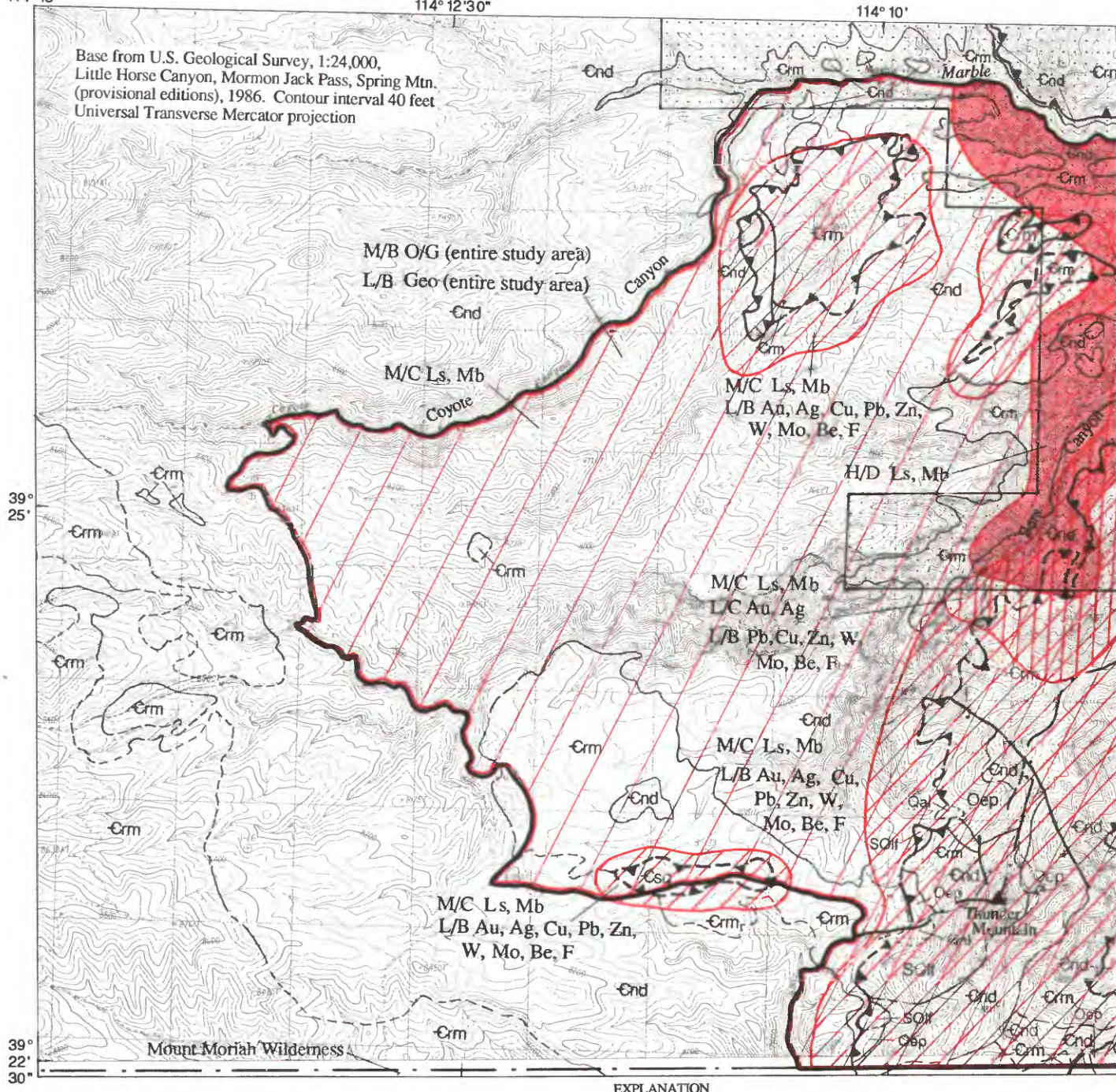
Methods and Background

Samples of sediment were collected at 47 sites on streams draining the wilderness study area and vicinity (fig. 3). Stream-sediment samples represent a composite of material eroded from the drainage basin of the stream sampled. Panned-concentrate samples derived from stream sediment contain selectively concentrated minerals that may be ore related and may include elements not easily detected in stream-sediment samples.

A stream-sediment sample and a panned-concentrate sample were collected at each site. The stream-sediment sample was air dried and then sieved through an 80-mesh stainless-steel sieve. The portion that passed through the screen was later pulverized to minus-100-mesh size prior to analysis. For the panned-concentrate sample at each site, enough stream sediment was screened through a 10-mesh sieve to obtain about 20 lb. The minus-10-mesh sample was panned to remove most of the quartz, feldspar, carbonate-rock material, clay-sized material, and organic matter. Most of the panned-concentrate samples were further concentrated by a series of steps that used bromoform (specific gravity 2.8) and magnetic separations to produce nonmagnetic heavy-mineral-concentrate samples that include most nonmagnetic ore minerals and accessory minerals such as sphene, zircon, apatite, and rutile. Prior to analysis, the 44 nonmagnetic heavy-mineral-concentrate samples were pulverized to minus-100-mesh size.

The stream-sediment and nonmagnetic heavy-mineral-concentrate samples were analyzed by emission spectrography for antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gold, iron, lanthanum, lead, magnesium, manganese, molybdenum, nickel, niobium, scandium, silver, strontium, thorium, tin, titanium, tungsten, vanadium, yttrium, zinc, and zirconium. In addition, the nonmagnetic heavy-mineral-concentrate samples were analyzed for gallium, germanium, palladium, phosphorus, platinum, and sodium by emission spectrography. The stream-sediment samples were also analyzed for gold by graphite-furnace atomic absorption, for uranium by ultraviolet fluorimetry, and for antimony, arsenic, bismuth, cadmium, and zinc by inductively coupled plasma spectroscopy (ICP). Analytical data, sampling sites, and references to analytical methods are presented by Bullock and others (1989).

Base from U.S. Geological Survey, 1:24,000,
Little Horse Canyon, Mormon Jack Pass, Spring Mtn.
(provisional editions), 1986. Contour interval 40 feet
Universal Transverse Mercator projection



EXPLANATION

- Area having high mineral resource potential (H) for limestone and marble
- Area having moderate mineral resource potential (M) for oil and gas, limestone, and marble and low mineral resource potential (L) for geothermal energy
- Area having moderate mineral resource potential (M) for barite and for other commodities as listed
- Area having low mineral resource potential (L), certainty level C, for commodities as indicated
- Area having low mineral resource potential (L), certainty level B, for commodities as indicated
- Area having low mineral resource potential (L) for barite and other commodities as indicated

Levels of certainty of assessment

- B Data only suggest level of potential
- C Data give good indication of level of potential
- D Data clearly define level of potential

- Contact—Dashed where inferred
- - - - Fault—Dashed where approximately located, dotted where concealed; bar and ball on downthrown side
- ▲ --- Detachment fault—Dashed where approximately located. Sawteeth on upper plate

Description of map units

- Qal Alluvium (Quaternary)—Alluvial fan deposits, stream deposits of gravel, sand, and silt, and landslide materials
- Tv Volcanic rocks (Tertiary)—Gray to dark-gray plagioclase-phyric alkaline olivine basalt
- PMre Riepe Spring Limestone of Steele (1960) (Permian) and Ely Limestone (Permian to Mississippian), undivided—Medium-gray limestone of organic detrital material that forms alternating ledges and gentle slopes
- Dgs Guilmette Formation, Simonson Dolomite, and Sevy Dolomite, undivided (Devonian)—Medium-gray to dark-gray, microcrystalline to coarsely crystalline well-bedded dolomite and interbedded limestone
- SOlf Laketown Dolomite (Silurian) and Fish Haven Dolomite (Ordovician), undivided—Light-gray to dark-gray dolomite
- Oep Eureka Quartzite and Pogonip Group, undivided (Ordovician)—The Eureka Quartzite consists of white, fine-grained equigranular quartzite with minor dolomitic quartzite. The Pogonip Group consists of platy to thin-bedded, fine- to coarse-textured, gray detrital limestone
- nd Notch Peak Limestone and Dunderberg Shale, undivided (Upper Cambrian)—The Notch Peak Limestone consists of medium-gray massive limestone, locally dolomitized; contains chert lenses. The Dunderberg Shale consists of light-olive-gray to medium-olive-gray silty shale intercalated with thin beds of limestone
- rm Raiff Limestone of Young (1960) and Monte Neva Formation of Young (1960), undivided (Middle Cambrian)—Light-gray to dark-gray limestone
- sq Shale and quartzite (Lower Cambrian)—Unit includes the Pioche Shale. Dark-greenish-gray to olive-gray silty shale and clay shale intercalated with siltstone. Local beds of medium-grained quartzite

Figure 2. Mineral resource potential and generalized geology of Marble Canyon Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah.

Geology by Michael F. Diggles and Susan M. Marcus,
1987, 1990: most of it generalized from Jeffrey Lee
(1990) and Hose and Blake (1970, 1976)

APPROXIMATE BOUNDARY
OF
MARBLE CANYON
WILDERNESS STUDY AREA
(NV-040-086)

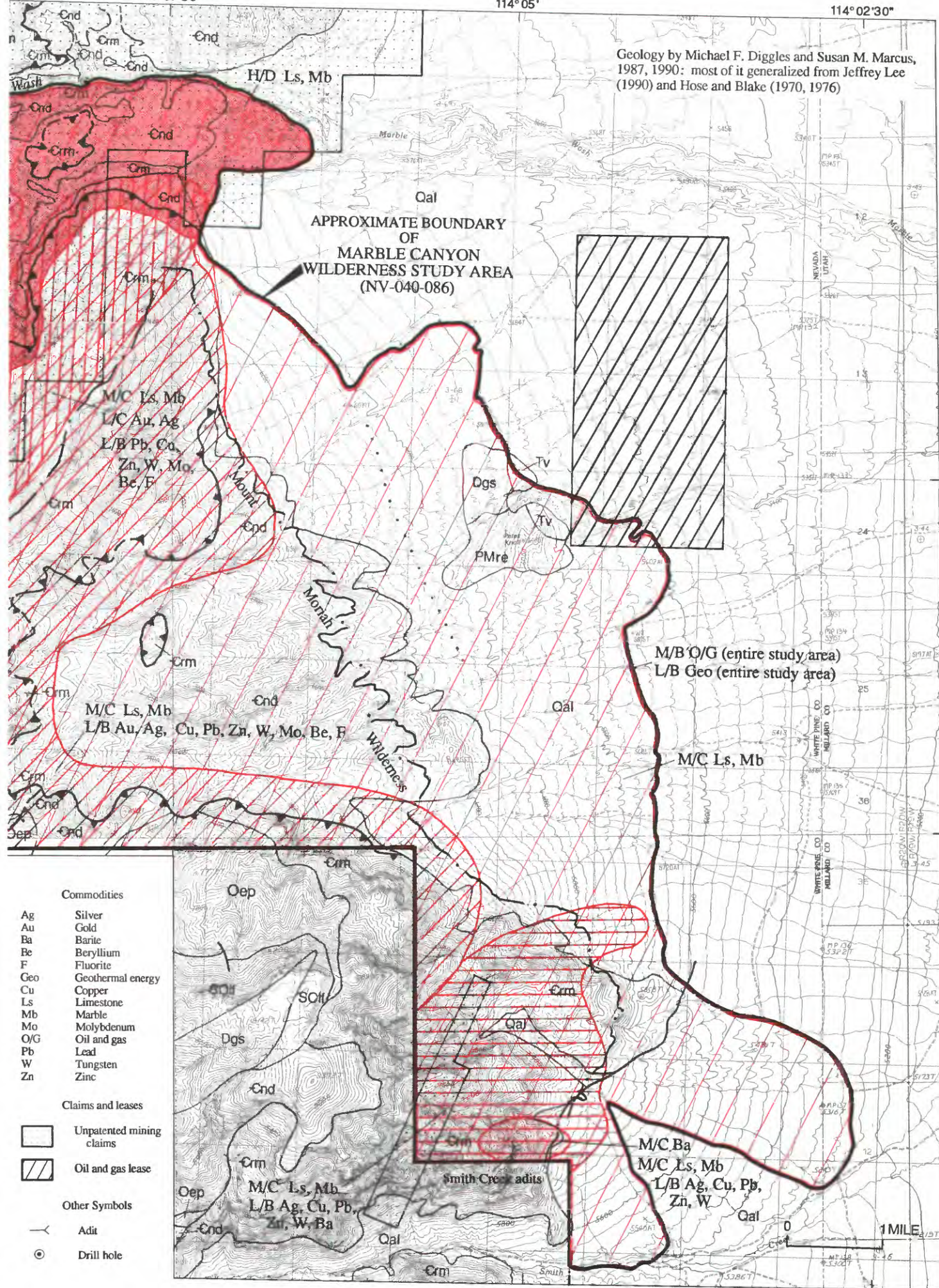


Table 1 lists selected elements determined in each sample type and, for each of them the lower and upper limits of determination, the range of concentrations, the 50th and 90th percentile concentrations, and the threshold (highest background) concentrations. Threshold concentrations were established by statistical and subjective examination of the data. The number of samples that have anomalous concentrations of each selected element is also given.

these two elements are usually associated with granitic rocks or pegmatites. The average concentration of beryllium in limestone is less than 1 part per million (ppm), and the average concentration of lanthanum in limestone is 4 ppm (Rose and others, 1979, p. 552, 567). Barium commonly accompanies base metals (copper, lead, zinc) in mineral deposits but also commonly forms bedded barite deposits in sedimentary rocks that have no significant amounts of base metals. Therefore, it is not unusual that anomalous concentrations of barium in samples sometimes accompany anomalous concentrations of other elements and sometimes do not.

Many samples from throughout the study area contain anomalous concentrations of only a single element or none. Samples from a few drainage basins contain anomalous concentrations of two to eight elements. Several geochemically anomalous areas, delineated A-D on figure 3, have similar

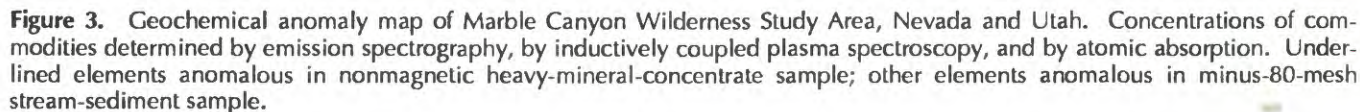


Table 1. Statistics for selected elements in drainage samples collected in and near the Marble Canyon Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah

[Results based on analyses of 47 stream-sediment samples and 44 nonmagnetic heavy-mineral-concentrate samples. Determined by emission spectrography, by inductively coupled plasma spectroscopy (suffix -i), and by atomic absorption (suffix -a). N, not detected at lower limit of determination; L, detected below lower limit of determination; G, greater than upper limit of determination; <, less than lower limit of determination; —, upper limit is open ended]

Element	Limits of determination, ppm		Range, ppm		Percentiles, ppm		Threshold concentration, ppm	Number of samples having anomalous concentrations
	Lower	Upper	Minimum	Maximum	50th	90th		
Minus-80-mesh stream-sediment samples								
Ag	0.5	5,000	N	L	N	N	N	3
As-i	5	20,000	<	36	8	16	14	6
Au-a	0.001	—	<	0.007	0.001	0.001	0.001	1
Ba	20	5,000	150	1,500	300	700	700	1
Be	1	1,000	N	5	2	3	3	4
La	20	1,000	N	100	20	50	50	3
Mo	5	2,000	N	L	N	N	N	2
Sb-i	2	20,000	<	2	<	<	<	1
Zn	200	10,000	N	L	N	N	N	4
Zn-i	2	18,000	11	60	39	53	49	10
Nonmagnetic heavy-mineral-concentrate samples								
B	20	5,000	N	300	N	100	100	3
Ba	50	10,000	L	G	600	G	3,000	8
Be	2	2,000	N	15	N	4	7	3
Bi	20	2,000	N	70	N	N	N	2
Co	20	5,000	N	50	N	L	L	3
Cu	10	50,000	N	30	N	13	10	5
La	100	2,000	N	300	L	100	150	3
Pb	20	50,000	N	G	70	1,000	700	7
Sn	20	2,000	N	100	N	L	N	6
Sr	200	10,000	N	2,000	N	200	300	1
W	50	20,000	N	50	N	N	N	4
Zn	500	20,000	N	10,000	N	N	N	4

geochemical signatures that are centered on anomalous concentrations of lead and zinc. The anomalous concentrations of lead and zinc are accompanied by anomalous concentrations of silver, gold, arsenic, barium, beryllium, bismuth, boron, cobalt, copper, lanthanum, tin, strontium, or tungsten; silver and gold are considered the most important after lead and zinc. The intensity of the geochemical anomaly of area A is the greatest, and that of area D is the least.

Anomalous areas A–D include a few adjoining drainage basins that have single-element anomalies. Beryllium and lanthanum are not included as contributors to multiple-element anomalies. When they are omitted, a few basins having them become single-element basins and are not included in the anomalous areas. However, an anomalous concentration of any element may be significant, and figure 3 only portrays relative significance.

Samples from some drainage basins contain anomalous concentrations of from one to many elements (fig. 3). Except for beryllium and lanthanum, the elements present in anomalous concentrations are compatible with the possible exist-

ence of at least two models of mineral deposition. The first model is the polymetallic replacement deposit (Morris, 1986; Mosier and others, 1986), and the second is deposits associated with detachment faults (Bouley, 1986; Spencer and Welty, 1986).

A carbonate replacement deposit, the Silver Peak mine, is about 5 mi southwest of the wilderness study area. Recorded production from the mine is 275 oz silver, 0.06 oz gold, and about 38,000 lb of lead (Smith, 1976). Polymetallic replacement deposits characteristically occur in limestone, dolomite, and shale that have been intruded by plutons (Morris, 1986). Igneous bedrock is not present in the sampled area, but intrusions are less than 2 mi from the southwest side of the wilderness study area, and volcanic rocks are less than 1 mi from the east side (Hose and Blake, 1976). Igneous rocks that were not detected in the geophysics study may be present beneath the upper-plate terrain that covers extensive areas of the wilderness study area. The presence of concealed granitic rocks could explain the anomalous concentrations of beryllium and lanthanum as well as the elements that are included

in the geochemical signature interpreted here as possibly representing carbonate replacement deposits related to igneous intrusions. Barton (1987) observed that two-mica granites that intrude carbonate host rocks can give rise to a characteristic lithophile-element suite including beryllium, fluorine, tungsten, molybdenum, and zinc.

The detachment-fault model of mineral deposition (Spencer and Welty, 1986) does not require the presence of igneous rocks. The most intense geochemical anomalies in the sampled area are spatially associated with detachment faults. Alteration associated with detachment faults is probably the most reasonable explanation for the geochemical anomalies in the sampled area.

Geophysics

Regional aeromagnetic and gravity maps for the Marble Canyon Wilderness Study Area and vicinity have been examined for indications of mineral resources. Two sources of aeromagnetic data have been utilized: surveys of the Ely, Nev., and Delta, Utah, 1° by 2° quadrangles flown for the National Uranium Resource Evaluation (NURE) program, and a survey of east-central Nevada flown for the U.S. Geological Survey (U.S. Geological Survey, 1978). The NURE traverses

were flown east-west at a nominal 400 ft above ground and 3-mi spacings, and the U.S. Geological Survey traverses were flown on east-west headings at 12,000 ft barometric elevation and 4-mi spacings. The main source of gravity data was the National Solar-Terrestrial and Geophysical Data Center in Boulder, Colo., which supplied principal facts for about 295 stations distributed mainly in low-lying sections of the area of interest. These data were supplemented by 13 additional stations established during July 1988 specifically to improve coverage in remote portions. It should be noted that the area considered in the geophysics interpretation is necessarily much larger than the area encompassed by the wilderness study area, which includes only seven gravity stations.

Aeromagnetic Data

The anomalous aeromagnetic field after removal of the International Geomagnetic Reference Field (IGRF) was computed from data of the NURE surveys (fig. 4). Because the traverse spacing is wide compared to the flight elevation, the shapes of short-wavelength features of the field are not accurately depicted. Sources of most of the anomalies are unknown. Volcanic rocks, which crop out in the northern part of the map area, have aeromagnetic signatures ranging from

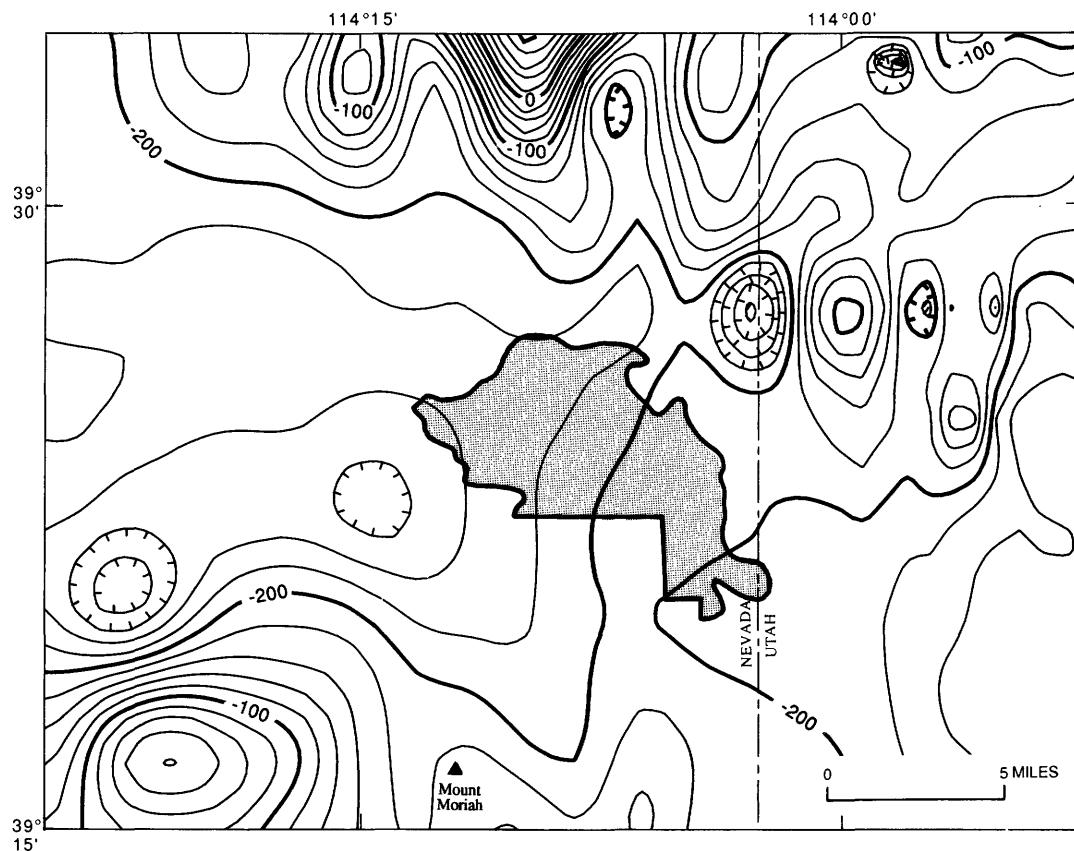


Figure 4. Aeromagnetic anomaly map of region including Marble Canyon Wilderness Study Area, Nevada and Utah (shaded area). Contour interval 20 nanoteslas, hachures indicate closed areas of lower values.

negligible to very intense and of relatively short wavelength. Outcrops of intrusive rock south of the study area have no detectable aeromagnetic expression. Long-wavelength positive anomalies of unknown origin north and southwest of the wilderness study area cover areas underlain by mostly Paleozoic rock or unconsolidated alluvium. The wilderness study area is within a broad, west-northwest-trending anomalous trough between relatively positive areas where the magnetic field is more disturbed. The origin of this trough is speculative, but it may reflect a structural depression in the crystalline basement. No aeromagnetic evidence suggests that the wilderness study area is underlain by intrusive rocks or contains concealed structural discontinuities. However, the Jurassic and Cretaceous two-mica granites of the region are notable for their absence of a strong aeromagnetic signature (Grauch and others, 1988).

Gravity Data

The complete Bouguer anomaly field, terrain-corrected to a distance of 42 mi (Hayford-Bowie zones A–O), is shown

in figure 5. All data reduction and terrain corrections employed a standard density of 2.67 g/cm³ and followed conventional U.S. Geological Survey procedures (see, for example, Cordell and others, 1982). The anomalous gravity field bears little resemblance to the aeromagnetic field. The anomalies have no direct correlation of anomalies with outcrops of volcanic or intrusive rocks; the only apparent consistency is that the most positive areas are largely associated with exposed bedrock. The main sources of positive anomalies are expected to be thick sections of Paleozoic miogeoclinal carbonate rocks or possibly carbonate rocks that have a core of elevated Proterozoic crystalline basement. A significant maximum, possibly reflecting a basement rise (Hose, 1981), occurs 5 to 6 mi southeast of Mount Moriah. Minima are produced mostly by thick accumulations of unconsolidated material and occur in the Snake Valley to the east or in Spring Valley and its adjuncts to the west of the wilderness study area. A major structural discontinuity on the east side of the Snake Range is indicated by the steep anomaly gradient east-southeast of the wilderness study area, several miles east of the nearest outcrops; terrain between this feature and the range front is

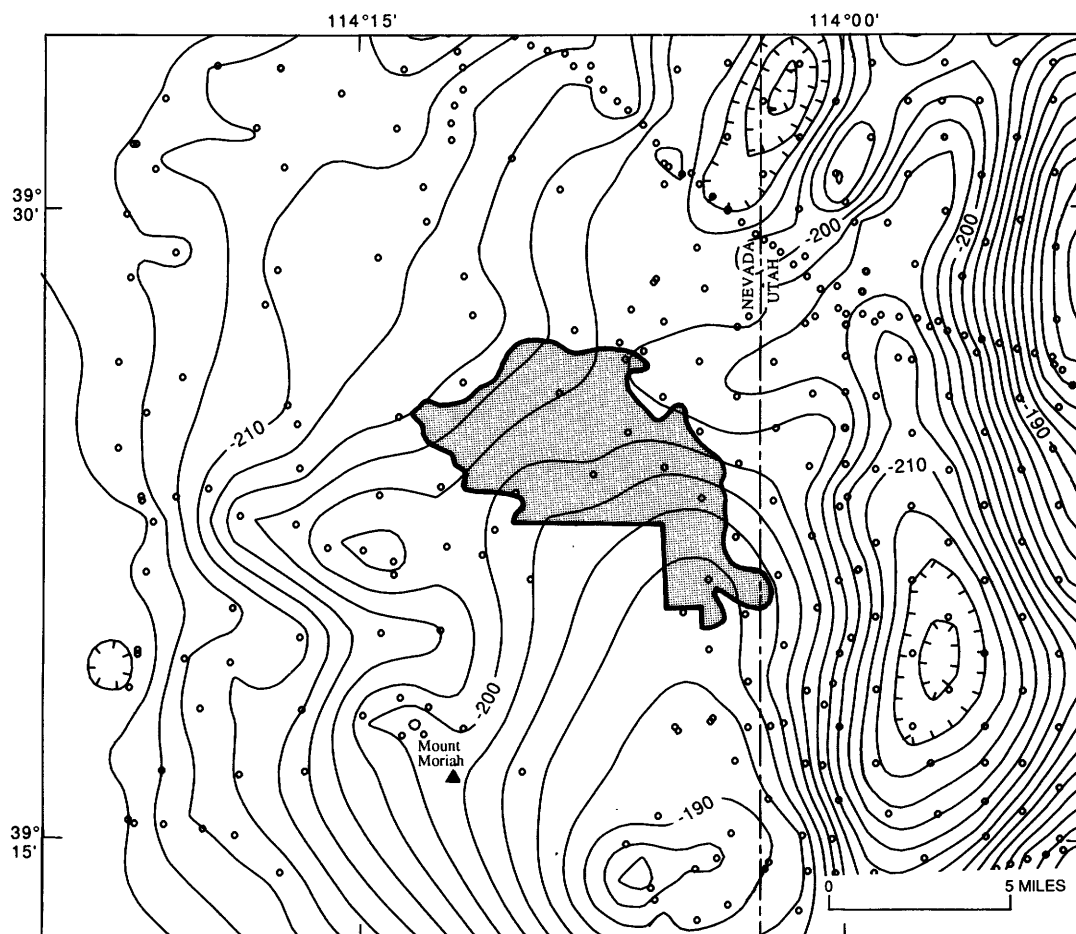


Figure 5. Bouguer gravity anomaly map of region including Marble Canyon Wilderness Study Area, Nevada and Utah (shaded area). Contour interval, 2 milligals; hachures indicate closed areas of lower gravity. Open circles represent gravity stations.

probably an extensive pediment. No structural discontinuities can be identified from the gravity field within the boundaries of the wilderness study area. Absence of geophysical evidence of buried plutons reduces the likelihood that there may be pluton-related resources at depth. Such a pluton could be present, but only if it lacked a notable aeromagnetic signature; the data are permissive for the presence of a buried two-mica granite such as those described by Grauch and others (1988).

The gravity field southwest of figure 5 is not well constrained, but anomaly values that appear to fall off steadily to the southwest toward Sacramento Pass suggest an increase in thickness of the relatively low density Proterozoic and Lower Cambrian quartzite section in that direction.

Mineral Resource Potential

Limestone and Marble

The lower parts of Bars Canyon and Marble Wash have high mineral resource potential, certainty level D, for medium-purity limestone and marble for use as aggregate. The rest of the wilderness study area may have pockets of medium-purity limestone and marble, although we saw none that have the purity of that observed in the canyons. The rest of the wilderness study area, therefore, has moderate mineral resource potential, certainty level C, for limestone and marble for use as aggregate.

Gold and Silver

Parts of the Marble Canyon Wilderness Study Area underlain by rocks of the upper plate and the zone of the northern Snake Range décollement have low mineral resource potential for gold and silver associated with detachment faults. Bouley (1986) described detachment-fault-type deposits. As so few such deposits are being mined, a grade-tonnage model has yet to be developed (D.A. Singer, oral commun., 1989). Gans and others (1988) suggested that the northern Snake Range décollement may be a rotated normal fault. If this is the case, the appropriate model would be carbonate-hosted gold-silver deposit described by Berger (1986) and Bagby and others (1986). With either model, the mineral resource potential for gold and silver is low, certainty level C, in the southeast side of lower Bars Canyon, where the geochemical data more strongly support this assessment. Other areas near the décollement, including both the upper and lower plates, have low mineral resource potential, certainty level B, for gold and silver.

Copper, Lead, and Zinc

Geochemical evidence suggests that parts of the study area underlain by the upper-plate rocks and the zone of the

northern Snake Range décollement or projections of that structure extending east and south to the Mount Moriah Division of Humboldt National Forest (Carlson and others, 1984) have low resource potential, certainty level B, for copper, lead, and zinc.

Tungsten and Molybdenum

The geophysical study does not suggest that plutons are concealed beneath the study area, but the two-mica granites of the region are notable for their lack of geophysical expression (Grauch and others, 1988). Anomalous concentrations of tungsten and (or) molybdenum in stream-sediment and fault-breccia samples collected from scattered parts of the study area could be explained if a buried pluton were present. The detachment fault could also have provided a locus for concentration of the metals. Parts of the study area underlain by the upper-plate rocks and the zone of the northern Snake Range décollement have low mineral resource potential, certainty level B, for tungsten and molybdenum.

Beryllium and Fluorite

Although there are beryllium and fluorite deposits in the Pioche Shale about 30 mi to the south in the Wheeler Peak region in the southern Snake Range (Whitebread and Lee, 1961), those deposits are confined to an (informal) limestone unit locally known as the "Wheeler limestone" in the lower part of the Pioche. A possible source of the beryllium is a quartz monzonite stock that intrudes the Wheeler Peak area (Whitebread and Lee, 1961). The Pioche Shale (part of map unit ϵ sq) crops out in the southwestern part of the study area, but the so-called Wheeler limestone does not extend into the northern Snake Range; mineralization due to the intrusion of the stock is confined to the Wheeler Peak area. The geophysical study did not show evidence that plutons are buried beneath the study area; however, the Snake Range is known for the presence of two-mica plutons that have no geophysical signature (Grauch and others, 1988). Anomalous concentrations of beryllium in geochemical samples collected from the study area could be explained by a buried two-mica pluton (Barton, 1987). The detachment fault could also have provided a locus for concentration of the beryllium. Parts of the study area underlain by the upper-plate rocks and the zone of the northern Snake Range décollement have low mineral resource potential, certainty level B, for beryllium and fluorite.

Barite

Barite is present in the walls of two adits that are just inside the southeast boundary of the study area (Kness, 1989), and anomalous concentrations of barium (greater than 10,000 ppm, Bullock and others, 1989) were measured in the panned concentrate from the basin west of the adits. Therefore, a

zone around the adits has moderate mineral resource potential, certainty level C, for barite, and the surrounding area has low mineral resource potential, certainty level B, for barite. On the basis of geochemical data, the zone around the adits and the surrounding area also have low mineral resource potential, certainty level B, for silver, copper, lead, zinc, and tungsten.

Oil and Gas

Sandberg (1982, 1983) evaluated the petroleum potential of wilderness lands in Nevada by using the following four major parameters that govern oil and gas accumulation: presence of source rocks, hydrocarbon maturation, reservoir rocks, and traps. He rated the Marble Canyon Wilderness Study Area as having medium potential because of optimum maturity of source rocks in the Devonian and Mississippian Pilot Shale and the Mississippian Chainman Shale. However, the only Devonian through Permian rocks in the study area are east of the range-front fault, and the Pilot and Chainman are missing there. Metamorphosed lower-plate rocks, thin sequences of faulted upper-plate rocks, and extrusive volcanic rocks exposed in the study area may preclude the presence of hydrocarbons. Therefore, the oil and gas resource potential is moderate in the entire study area, but, on the basis of the degree of metamorphism of the possible lower-plate source rocks and the faulting and tilting of possible upper-plate trap rocks, this assessment could be too high. The certainty level of assessment, therefore, is B.

Geothermal Energy

Bliss (1983) lists geothermal springs and wells for the Ely 1° by 2° quadrangle. He shows two thermal springs in Spring Valley west of the study area. We observed thermal springs just east of the study area, 1 mi across the Nevada-Utah State line on the road to Gandy. Range-front faulting may be providing a conduit for thermal water, and that system could extend into the study area. The entire Marble Canyon Wilderness Study Area has low geothermal energy potential, certainty level B, for low-temperature thermal springs.

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APPENDIXES

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

LEVELS OF RESOURCE POTENTIAL

- H **HIGH** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.
- M **MODERATE** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood for resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.
- L **LOW** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is permissive. This broad category embraces areas with dispersed but insignificantly mineralized rock, as well as areas with little or no indication of having been mineralized.
- N **NO** mineral resource potential is a category reserved for a specific type of resource in a well-defined area.
- U **UNKNOWN** mineral resource potential is assigned to areas where information is inadequate to assign a low, moderate, or high level of resource potential.

LEVELS OF CERTAINTY

- A Available information is not adequate for determination of the level of mineral resource potential.
- B Available information only suggests the level of mineral resource potential.
- C Available information gives a good indication of the level of mineral resource potential.
- D Available information clearly defines the level of mineral resource potential.

	A	B	C	D
<div style="display: flex; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">LEVEL OF RESOURCE POTENTIAL</div> <div style="margin-left: 10px;"> </div> </div>	U/A	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
	UNKNOWN POTENTIAL	M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL
		L/B LOW POTENTIAL	L/C LOW POTENTIAL	L/D LOW POTENTIAL
				N/D NO POTENTIAL
	<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">LEVEL OF CERTAINTY</div> <div style="flex-grow: 1; text-align: center;"> </div> </div>			

Abstracted with minor modifications from:

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RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES		UNDISCOVERED RESOURCES	
	Demonstrated		Probability Range	
	Measured	Indicated	Hypothetical	Speculative
ECONOMIC	Reserves	Inferred Reserves		
MARGINALLY ECONOMIC				
SUB-ECONOMIC				

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from McKelvey, V.E., 1972, Mineral resource estimates and public policy: American Scientist, v. 60, p. 32-40; and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

EON	ERA	PERIOD		EPOCH	AGE ESTIMATES OF BOUNDARIES IN MILLION YEARS (Ma)
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
				Mesozoic	Cretaceous
					138
	Jurassic		Late Middle Early		
					205
	Triassic		Late Middle Early		
					~240
	Paleozoic	Permian		Late Early	
		Carboniferous Periods	Pennsylvanian	Late Middle Early	290
					~330
			Mississippian	Late Early	
		Devonian		Late Middle Early	360
					410
		Silurian		Late Middle Early	
			435		
Ordovician		Late Middle Early			
			500		
Cambrian		Late Middle Early			
Proterozoic	Late Proterozoic			1~570	
	Middle Proterozoic			900	
	Early Proterozoic			1600	
Archean	Late Archean			2500	
	Middle Archean			3000	
	Early Archean			3400	
pre-Archean ² (3800?)					
					4550

¹Rocks older than 570 Ma also called Precambrian, a time term without specific rank.

²Informal time term without specific rank.

Mineral Resources of
Wilderness Study Areas—
East-Central Nevada and
Part of Adjacent Beaver and
Iron Counties, Utah

This volume was published as separate chapters A–G

U.S. DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, Jr., Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director



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- (B) Mineral Resources of the White Rock Range Wilderness Study Area, Lincoln County, Nevada, and Beaver and Iron Counties, Utah, by Margo I. Toth, Rebecca G. Stoneman, H. Richard Blank, Jr., and Diann D. Gese.
- (C) Mineral Resources of the Far South Egans Wilderness Study Area, Lincoln and Nye Counties, Nevada, by D.C. Hedlund, R.C. Davies, D.S. Hovorka, H.R. Blank, Jr., and S.E. Tuftin.
- (D) Mineral Resources of the Parsnip Peak Wilderness Study Area, Lincoln County, Nevada, by Margo I. Toth, Rebecca G. Stoneman, H. Richard Blank, Jr., and Diann D. Gese.
- (E) Mineral Resources of the Weepah Spring Wilderness Study Area, Lincoln and Nye Counties, Nevada, by Edward A. du Bray, H.R. Blank, Jr., Robert L. Turner, Diann D. Gese, and Albert D. Harris.
- (F) Mineral Resources of the Mount Grafton Wilderness Study Area, Lincoln and White Pine Counties, Nevada, by R.E. Van Loenen, H.R. Blank, Jr., Harlan Barton, and M.L. Chatman.
- (G) Mineral Resources of the Marble Canyon Wilderness Study Area, White Pine County, Nevada, and Millard County, Utah, by Michael F. Diggles, Gary A. Nowlan, H. Richard Blank, Jr., Susan M. Marcus, and Richard F. Kness.

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